Natural Conditions Assessment for Low pH, Hoskins Creek and Tributaries in Essex County and Town of Tappahannock, Virginia

Submitted by
Virginia Department of Environmental Quality

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Executive Summary

This report presents the assessment of whether low pH in Hoskins Creek and tributaries are due to natural conditions or whether a Total Maximum Daily Load (TMDL) must be performed because of anthropogenic impacts. Hoskins Creek and tributaries including two Unnamed Tributaries to Hoskins Creek and Church Swamp, located within Essex County and the Town of Tappahannock, Virginia, are minor tributaries to the Rappahannock River. Hoskins Creek and tributaries encompass approximately 66.22 rivermiles from the National Hydrography Dataset (NHD). The tidal portion includes 0.1542 mi^2. The waterbody identification code (WBID, Virginia Hydrologic Unit) for the non-tidal Hoskins Creek and tributaries is VAP-E23R. The waterbody identification code for the tidal Hoskins Creek is VAP-E23E. Hoskins Creek and tributaries were listed as impaired due to violations in water quality standards for pH. This report addresses the pH impairment.

The total area of the watershed is approximately 29.59 square miles. The average annual rainfall is 42.31 inches. The watershed is approximately 18939 acres (29.6 mi^2) in size and is predominately forested (63.5 percent). Agriculture comprises 24.5 percent of the watershed, with 10.2 percent cropland and 14.3 percent pasture/hayland. Urban areas compose approximately 2.4 percent of the land base. The remaining 3.9 percent of the watershed is comprised of barren areas, and 5.8 percent wetlands and open water.

The mainstem of Hoskins Creek was listed as impaired on Virginia's 2004 305(b) / 303(d) Integrated Report (IR) and the impairment continued in the 2006 and 2008 IRs (VADEQ, 2004, 2006, and 2008) due to violations of the State's water quality standard for pH. The mainstem of Church Swamp was listed as impaired on Virginia's 2006 305(b) / 303(d) IR and the impairment continued in the 2008 IR (VADEQ, 2006 and 2008) due to violations of the State's water quality standard for pH. The mainstem of Unnamed Tributaries XGX and XGY to Hoskins Creek were listed as impaired on Virginia's 2008 305(b) / 303(d) IR due to violations of the State's water quality standard for pH (VADEQ, 2008). The mainstem of tidal Hoskins Creek from the head of tide downstream to the mouth of Church Swamp was listed as impaired on Virginia's 2006 305(b) / 303(d) IR due and the impairment continued in the 2008 IR (VADEQ, 2006 and 2008) due to violations of the State's water quality standard for pH. This report evaluates the pH impairments by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL.

DEQ monitored 7 stations on non-tidal Hoskins Creek and tributaries and 2 stations on tidal Hoskins Creek and tributaries with dates ranging from June 2001 through April 2007. Of the 160 total pH data points recorded, 95 violated water quality standards for pH (59%). The pH minimum and maximum values ranged from 4.31 to 7.10 mg/L. Time series graphs of all pH data collected at the two original listing stations, 3-HOK011.45, Hoskins Creek at Rt. 717, and 3-HOK007.25, Hoskins Creek at Rt. 618, shows the pH ranging from 4.61 to 6.90 (Figures E1 and E2). The horizontal line at the pH = 6.0 mark represents the minimum water quality standard. The data points below the pH = 6.0 line illustrate violations of the water quality standard.

Figure E1. Time series of pH at Hoskins Creek at Rt. 717, (station 3-HOK011.45).

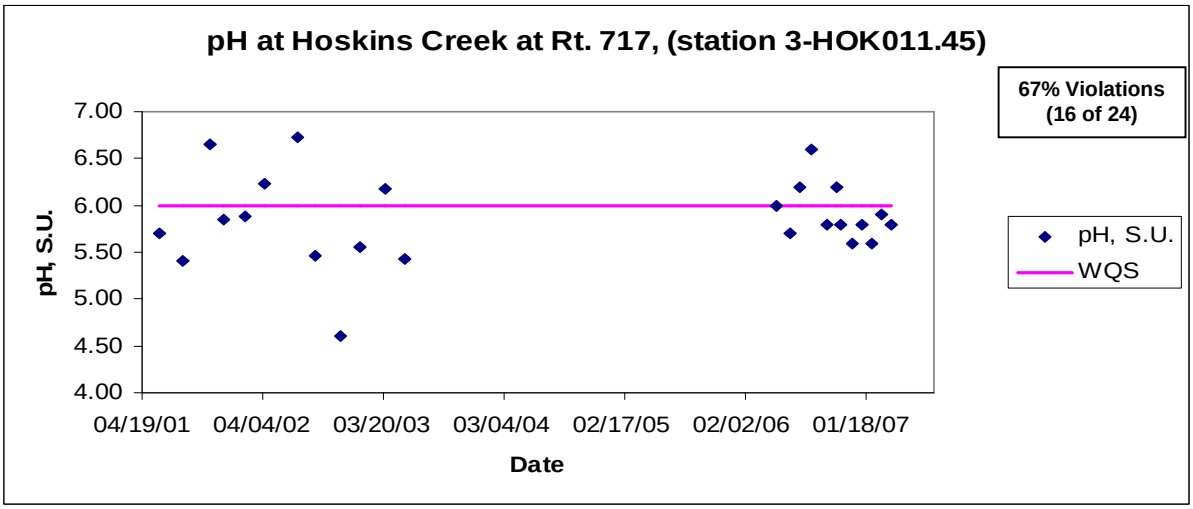
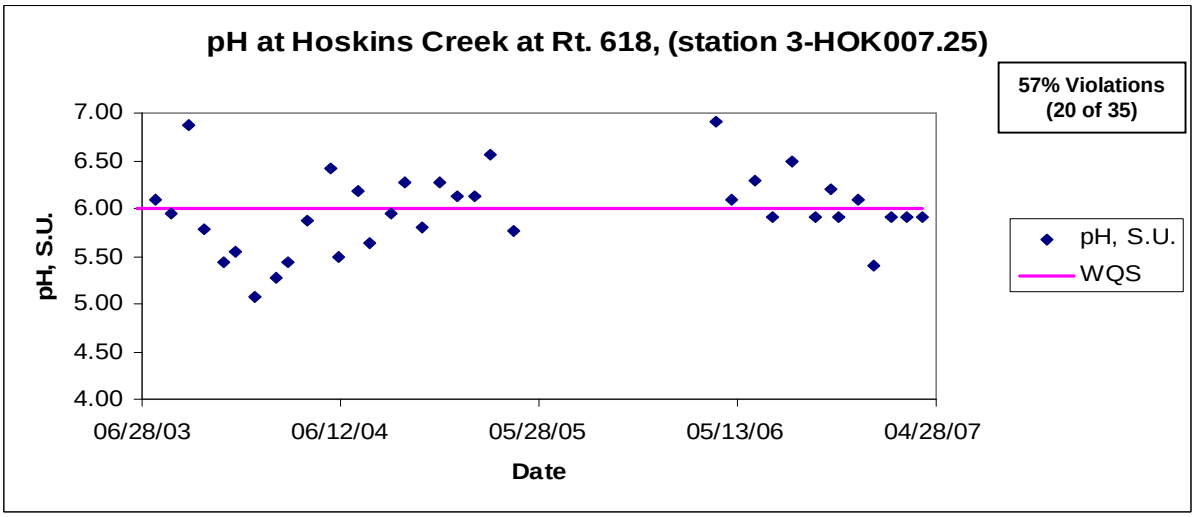


Figure E2. Time series of pH at Hoskins Creek at Rt. 618, (station 3-HOK007.25).



According to Virginia Water Quality Standards (9 VAC 25-260-10A), "all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."

As indicated above, the Hoskins Creek tributaries must support all designated uses and meet all applicable criteria. If the waterbody pH values are less than 6.0 or greater than 9.0 in more than 10.5 percent of samples, the waterbody is classified as impaired and natural conditions must be determined or a TMDL must be developed and implemented to bring the waterbody into compliance with the water quality criterion.

In 2003 VADEQ proposed a methodology for determining whether low DO or pH originates from natural or anthropogenic sources, adapted from "Methodology for Assessing Natural Dissolved Oxygen and pH Impairments: Application to the Appomattox River Watershed, Virginia" (MapTech 2003).

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. Conditions that would typically be associated with naturally low DO include slow-moving, ripple-less waters where the bacterial decay of organic matter depletes DO at a faster rate than it can be replenished. Indicators of these conditions include low slope, the presence of swamps or wetlands. These conditions often also produce low pH due to organic acids (tannins, humic and fulvic substances) produced in the decay process. These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems.

The general approach to determine if DO and pH impairments in free-flowing streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or low pH levels and for determining the likelihood of anthropogenic impacts is described below. DEQ staff use this approach to implement State Water Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Before implementing this procedure, all DO and pH data should be screened for flows less than the 7Q10. DO and pH data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly.

Step 1. Determine slope and appearance (presence of wetlands).
Step 2. Determine nutrient levels and compare with USGS background concentrations.
Step 3. Determine degree of seasonal fluctuation (for DO only).
Step 4. Determine anthropogenic impacts from permitted dischargers and land use.

No Hoskins Creek and tributaries pH standard violations were obtained at flows below 7Q10. One non-violation pH 6.72 S.U. on 7/17/2002 at station 3-HOK011.45 was obtained below 7Q10, but this was not deleted from the dataset per the established protocol, therefore no data were removed.

The low slope for these streams ranged from 0.17% to 0.41%, which is less than the defined low slope criteria of 0.50%. Decomposition of the large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watersheds contribute to low pH by creation of natural weak organic acids (tannic, humic and fulvic acids) during decomposition of the decaying vegetation, and increase oxygen demand and lower DO as they decay. These are not considered anthropogenic impacts. Criddlin and Church Swamps and UT Hoskins Creek at RM 9.45 were included in the report because their slopes meet the criteria for swampwater and each contains areas of forested land with swamps and heavy tree canopy throughout the watershed like the other tributaries in the study.

Hoskins Creek and its tributaries exhibit low nutrient concentrations below national background levels in streams from undeveloped areas, which are not indicative of human impact.

There are 4 active permitted (1 VPDES; 1 VAG; 2 VAR) Point Source facilities in the Hoskins Creek and tributaries watershed (E23E and R). All are located in the tidal portion of the watershed below the confluence with Church Swamp and so may only be expected to have any impact on upper tidal station 3-HOK003.61 above Church Swamp on incoming tides. The Town of Tappahannock STP (VA0071471) submitted 94 monthly effluent pH data points to VADEQ during the period of July 2002 to April 2010. The minimum was pH 6.1 S.U. and the maximum was pH 8.7 S.U. This facility would not lower pH in the upper tidal portion of Hoskins Creek. The VAG is a private residence with a design flow < 0.001 mgd located at the mouth of tidal Hoskins Creek at the Rappahannock River. The owner collects pH once annually and keeps the data onsite. The stormwater construction permit was in effect from June 2004 to June 2009 and was terminated in June 2009. The stormwater industrial permittee was located 0.75 mi from the tidal portion of Church Swamp and discharged only in significant rainfall events. These facilities are not expected to impact non-tidal Hoskins Creek pH at all, and are expected to have no significant impact to upper tidal Hoskins Creek pH. Visual inspections of Hoskins Creek and tributaries revealed swampy areas with heavy tree canopy. Decomposition of vegetative matter from large swampy areas lowers pH and DO as decay occurs.

Urban areas compose approximately 2.4 percent of the land base, almost all of which occurs downstream of the impaired segment in the tidal portion of the watershed. This leaves an insignificant portion of the urban land use in the non-tidal portion of the watershed. Agriculture makes up approximately 24.5 percent of the watershed. The watershed is predominately forested (63.5 percent), with 5.6 percent wetlands and 0.2 percent open water. Land use was not considered to have significantly impacted the swampwater conditions of Hoskins Creek and its tributaries.

Based on the above information, a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is indicated for Hoskins Creek and its non-tidal tributaries from their headwaters to the head of tide located in waterbody identification codes (WBID, Virginia Hydrologic Unit) E23R, a total of 66.22 rivermiles. Also a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is indicated for tidal Hoskins Creek from the head of tide downstream to the confluence of Church Swamp, totaling 0.052 mi^2, located in waterbody identification code E23E. If there is a 305(b)/303(d) assessment prior to the reclassification, Hoskins Creek and these tributaries will be assessed as Category 4C, Impaired due to natural condition, no TMDL needed.

DEQ performed the assessment of the Hoskins Creek tributaries low DO and low pH natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

1. Introduction

Hoskins Creek and tributaries including two Unnamed Tributaries to Hoskins Creek and Church Swamp, located within Essex County and the Town of Tappahannock, Virginia, are minor tributaries to the Rappahannock River. Hoskins Creek and tributaries encompass approximately 66.22 rivermiles. The tidal portion includes 0.1542 mi^2. Staff determined rivermiles from the USGS National Hydrography Dataset using GIS. Hoskins Creek and tributaries generally flow east from the headwaters south of Beazley, VA to the confluence with the Rappahannock River in Tappahannock, VA. Hoskins Creek is tidally influenced from approximately river mile 6.52 downstream to the confluence with the Rappahannock River. The watershed totals approximately 29.59 mi^2. There is no current continuous flow gaging station on Hoskins Creek, however USGS gaging station 01668800 at the Rt. 717 bridge recorded daily flows from October 1964 to January 1987, and peak flows until 2006.

2. Physical Settings

2.1. Listed Water Bodies

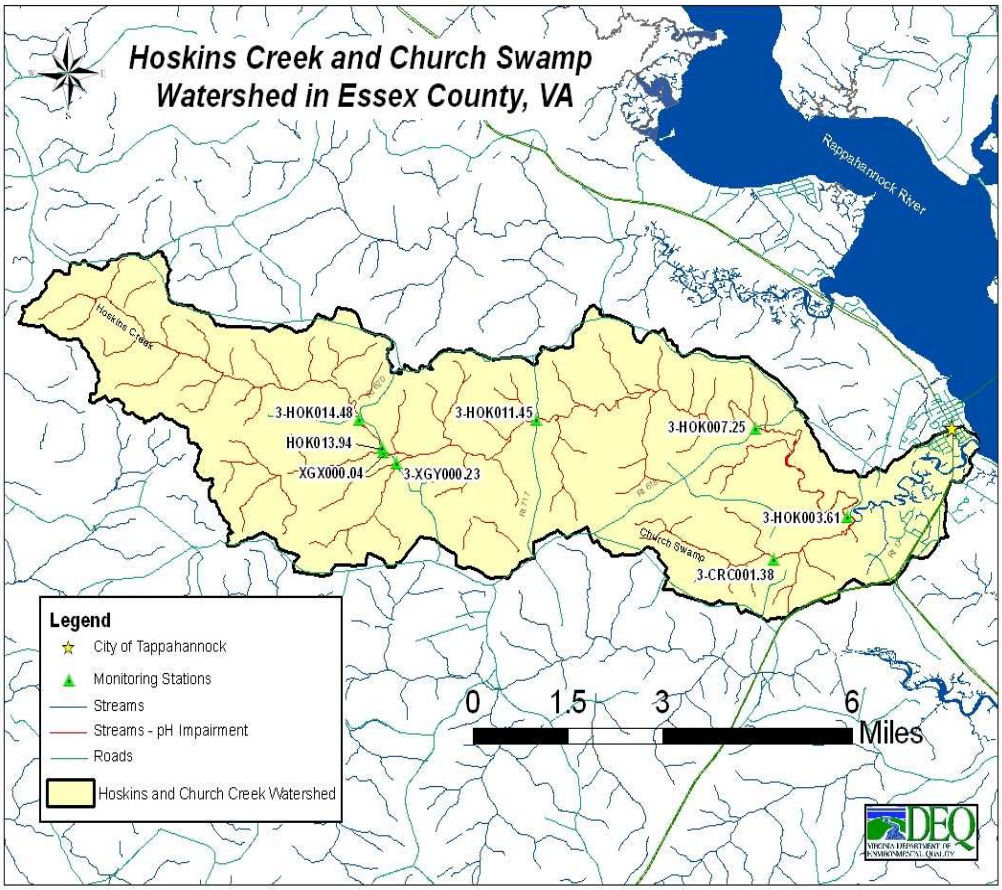
The mainstem of Hoskins Creek was listed as impaired on Virginia's 2004 305(b) / 303(d) Integrated Report (IR) and the impairment continued in the 2006 and 2008 IRs (VADEQ, 2004, 2006, and 2008) due to violations of the State's water quality standard for pH. The mainstem of Church Swamp was listed as impaired on Virginia's 2006 305(b) / 303(d) IR and the impairment continued in the 2008 IR (VADEQ, 2006 and 2008) due to violations of the State's water quality standard for pH. The mainstem of Unnamed Tributaries XGX and XGY to Hoskins Creek were listed as impaired on Virginia's 2008 305(b) / 303(d) IR due to violations of the State's water quality standard for pH (VADEQ, 2008). The mainstem of tidal Hoskins Creek from the head of tide downstream to the mouth of Church Swamp was listed as impaired on Virginia's 2006 305(b) / 303(d) IR due and the impairment continued in the 2008 IR (VADEQ, 2006 and 2008) due to violations of the State's water quality standard for pH. This report evaluates the pH impairments by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL. The waterbody identification code (WBID, Virginia Hydrologic Unit) for the non-tidal Hoskins Creek and tributaries is VAP-E23R and VAP-E23E for tidal Hoskins Creek.

2.2. Watershed

2.2.1. General Description

Hoskins Creek and tributaries flow east from the headwaters south of Beazley, VA to the confluence of the Rappahannock River at Tappahannock, VA. The total area of the watershed is approximately 29.59 square miles. See Figure 1 for a map of the watershed including monitoring stations.

Figure 1. The Hoskins Creek and tributaries watershed map and associated monitoring stations.



2.2.2. Geology, Climate, Land Use

Geology and Soils

The impaired segments of the Hoskins Creek and tributaries are predominately within the Atlantic Coastal Plain physiographic region, though the headwaters of some tributaries are located within the lower Piedmont physiographic province. The Atlantic Coastal Plain is the easternmost of Virginia's physiographic provinces. The Atlantic Coastal Plain extends from New Jersey to Florida, and includes all of Virginia east of the Fall Line. The Fall Line is the easternmost extent of rocky river rapids, the point at which east-flowing rivers cross from the hard, igneous and metamorphic rocks of the Piedmont to the relatively soft, unconsolidated strata of the Coastal Plain. The Coastal Plain is underlain by layers of Cretaceous and younger clay, sand, and gravel that dip gently eastward. These layers were deposited by rivers carrying sediment from the eroding Appalachian Mountains to the west. As the sea level rose and fell, fossiliferous marine deposits were interlayered with fluvial, estuarine, and beach strata. The youngest deposits of the Coastal Plain are sand, silt and mud presently being deposited in our bays and along our beaches (http://www.dcr.virginia.gov/natural_heritage/documents/overviewPhysiography_vegetation.pdf).

Soils for the Hoskins Creek watershed were documented utilizing the VA State Soil Geographic Database (STATSGO). Two general soil types were identified using in this database. Descriptions of these soil series were derived from queries to the USDA Natural Resources Conservation Service (NRCS) Official Soil Series Description web site (http://soils.usda.gov/technical/classification/osd/index.html). Figure 2 shows the location of these general soil types in the watershed.

Soils of the **Emporia-Johnston-Kenansville-Remlik-Rumford-Slagle-Suffolk-Tomotley (VA027)** series are very deep to deep, and vary between well drained to poorly drained with moderately slow or slow

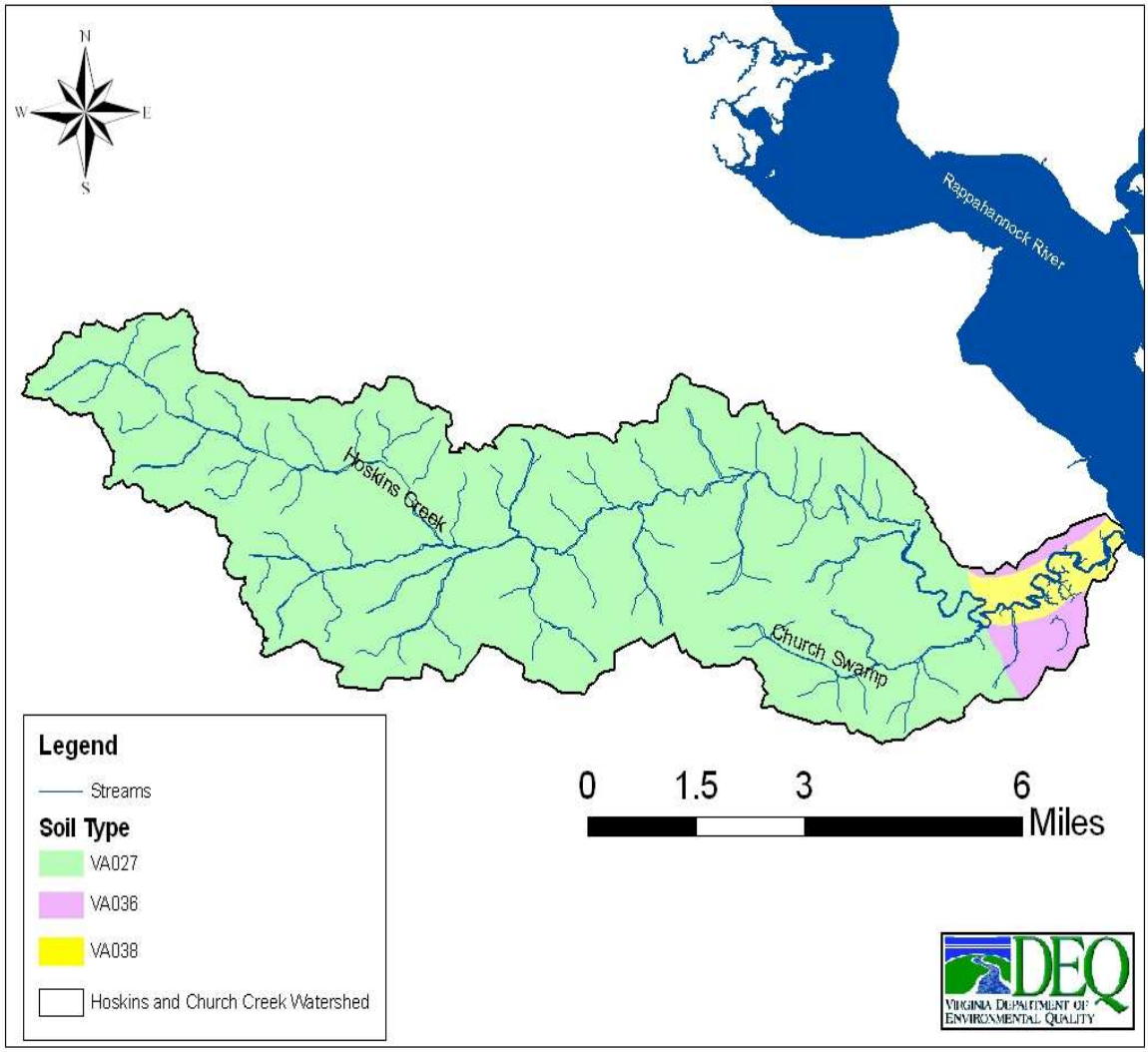
permeability. They formed in moderately fine-textured stratified fluvial and marine sediments on the upper Coastal Plain and stream terraces.

The soils of the **Craven-Mattaponi-Lenoir-Coxville (VA035)** series are very deep in which the drainage ranges from somewhat poor to well drained and the permeability is typically slow to moderately slow. The soils formed in flats or depressions from the lower to upper Coastal Plain and Piedmont Physiographic Provinces of the Atlantic Coast, in which the parent materials consists of fluvial and marine sediments.

Soils of the **Tetotum-Nansemond-State-Emporia-Dragston-Nimmo-Bladen (VA036)** series are very deep and range from well drained to poorly drained. Permeability ranges from moderately rapid and/or rapid to moderately slow or slow. This soil series was formed in sandy or loamy fluvial and marine sediments on Coastal Plain uplands and stream terraces.

Soils of the **Bibb and Levy-Bohicket-Lumbee-Nansemond-Rumford-Tetotum-State-Suffolk (VA037)** Series are very deep to deep, and vary from well drained to very poorly drained. They range in slope from 0 – 15 percent. Their water capacity varies from low to high. This soils series was formed in sandy to loamy to mucky clay alluvial and marine sediments on the upper Coastal Plain and stream terraces.

Figure 2. Soil Characteristics of the Hoskins Creek Watershed.



Climate

The climate summary for Hoskins Creek and tributaries is derived from a weather station located in Warsaw, VA, with a period of record from 1/ 1/1893 to 8/31/2009. The average annual maximum and minimum temperature (°F) at the weather station is 68.3 and 46.6, respectively and the annual rainfall is 42.31 inches (Table 1). (Southeast Regional Climate Center, http://www.sercc.com/climateinfo/historical/historical_va.html).

Table 1. Climate summary for Warsaw 2 N, Virginia (448894) as of March 2010

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	46.6	49.1	58.3	68.6	77.3	84.6	87.9	86.5	80.6	70.6	59.8	49.3	68.3
Average Min. Temperature (F)	27.4	28.3	35.5	44.2	53.7	62.5	66.6	65.7	59.0	47.7	38.3	30.0	46.6
Average Total Precipitation (in.)	3.13	2.82	3.73	3.12	3.80	3.82	4.48	4.47	3.72	3.20	2.93	3.11	42.31

Land Use

The Hoskins Creek and tributaries watershed extends approximately 10 miles from south of Beazley, VA to Tappahannock, VA, and is 2 - 3 miles wide. The watershed is approximately 18939 acres (29.6 mi^2) in size and is predominately forested (63.5 percent). Agriculture comprises 24.5 percent of the watershed, with 10.2 percent cropland and 14.3 percent pasture/hayland. Urban areas compose approximately 2.4 percent of the land base. The remaining 3.9 percent of the watershed is comprised of barren areas, and 5.8 percent wetlands and open water. Land use is described in Table 2.

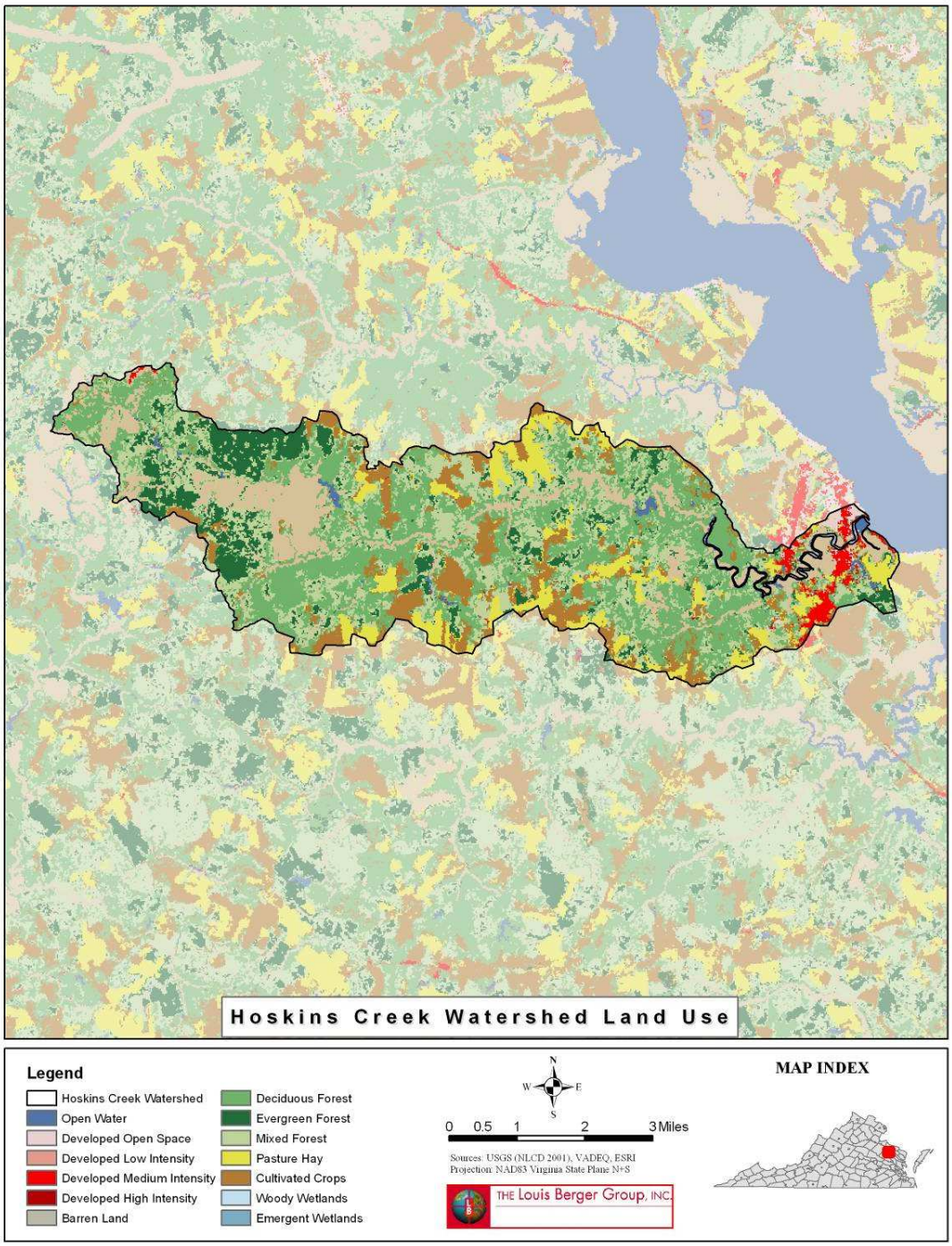
A map of the distribution of land use in the watershed (Figure 3) shows that urban land use and water land use are concentrated near the tidal mouth in Tappahannock, VA.

Table 2. Land Use in the Hoskins Creek and Tributaries Watershed

Hoskins Creek Landuse	Acres	%
Open Water	29	0.2%
Woody Wetlands	751	4.0%
Emergent Herbaceous Wetlands	295	1.6%
Developed, Open Space	139	0.7%
Developed, Low Intensity	133	0.7%
Developed, Medium Intensity	108	0.6%
Developed, High Intensity	69	0.4%
Deciduous Forest	7300	38.5%
Evergreen Forest	4581	24.2%
Mixed Forest	155	0.8%
Pasture/Hay	2700	14.3%
Cultivated Crops	1936	10.2%

Barren Land (Rock/Sand/Clay)	743	3.9%
Total	18939	100%

Figure 3. Land Use in the Hoskins Creek and Tributaries Watershed



3. Description of Water Quality Problem/Impairment

The mainstem of non-tidal Hoskins Creek was first listed as impaired on Virginia's 2004 303(d) Total Maximum Daily Load Priority List and Report (2004), due to violations of the State's water quality standard for pH. The mainstem of tidal Hoskins Creek from the head of tide downstream to the confluence with Church Swamp was first listed as impaired on Virginia's 2006 303(d) Total Maximum Daily Load Priority List and Report (2006), due to violations of the State's water quality standard for pH. The mainstems of two non-tidal unnamed tributaries to Hoskins Creek were first listed as impaired on Virginia's 2008 303(d) Total Maximum Daily Load Priority List and Report (2008), due to violations of the State's water quality standard for pH. This report evaluates the pH impairments by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL.

DEQ monitored 7 stations on non-tidal Hoskins Creek and tributaries and 2 stations on tidal Hoskins Creek and tributaries (Figure 1) with dates ranging from June 2001 through April 2007. Of the 160 total pH data points recorded, 95 violated water quality standards for pH (59%). The pH minimum and maximum values ranged from 4.31 to 7.10 mg/L. The results are summarized in Table 3.

Table 3. pH data collected by DEQ from 9 stations on Hoskins Creek and tributaries.

Station	Sample Period	pH	Average pH, S.U.	Min-Max pH	Number of Violations	% Violations
3-CRC000.15	4/3/2006 to 4/4/2007	13	6.26	5.90-7.10	1	8
3-CRC001.38	4/23/2003 to 10/17/2003	2	5.11	4.31-5.91	2	100
3-HOK003.61	7/21/2003 to 4/4/2007	36	6.11	5.64-6.72	13	36
3-HOK007.25	7/21/2003-4/4/2007	35	5.97	5.08-6.90	20	57
3-HOK011.45	6/6/2001-4/4/2007	24	5.86	4.61-6.72	16	67
3-HOK013.94	5/2/2006 to 4/4/2007	12	5.04	4.50-5.60	12	100
3-HOK014.48	5/2/2006 to 4/4/2007	12	5.08	4.50-5.90	12	100
3-XGX000.04	5/2/2006 to 4/4/2007	12	5.38	4.50-6.30	11	92
3-XGY000.23	5/2/2006 to 4/4/2007	12	5.88	5.30-6.40	8	67

Time series graphs of all pH data collected at the two original listing stations, 3-HOK011.45, Hoskins Creek at Rt. 717, and 3-HOK007.25, Hoskins Creek at Rt. 618, shows the pH ranging from 4.61 to 6.90 (Figures 4 and 5). The horizontal line at the pH = 6.0 mark represents the minimum water quality standard. The data points below the pH = 6.0 line illustrate violations of the water quality standard in Figures 4 and 5.

Figure 4. Time series of pH at Hoskins Creek at Rt. 717, (station 3-HOK011.45).

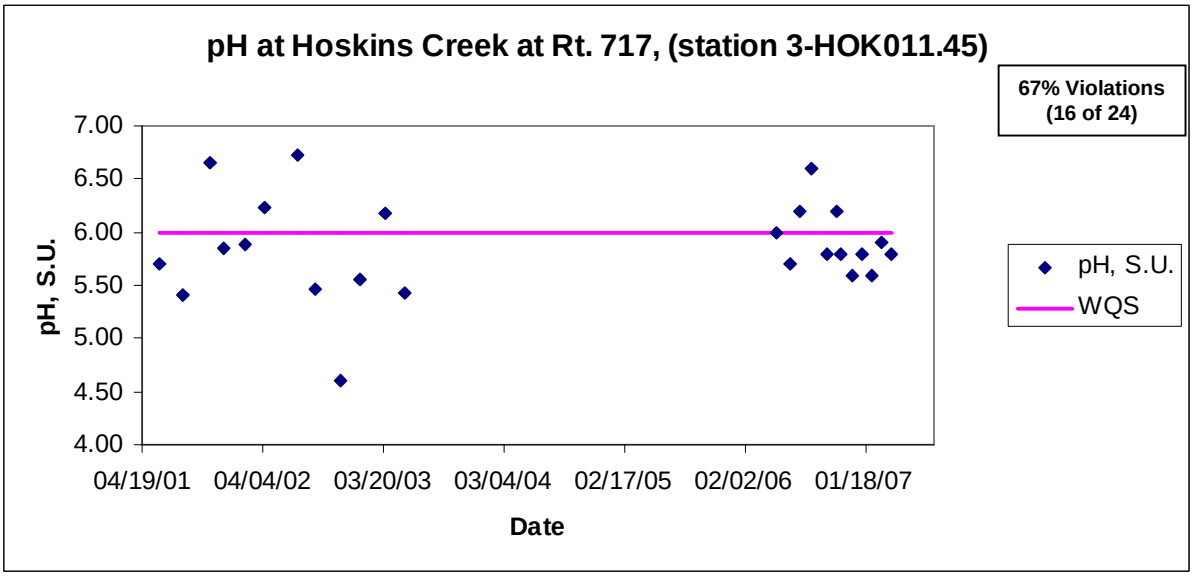
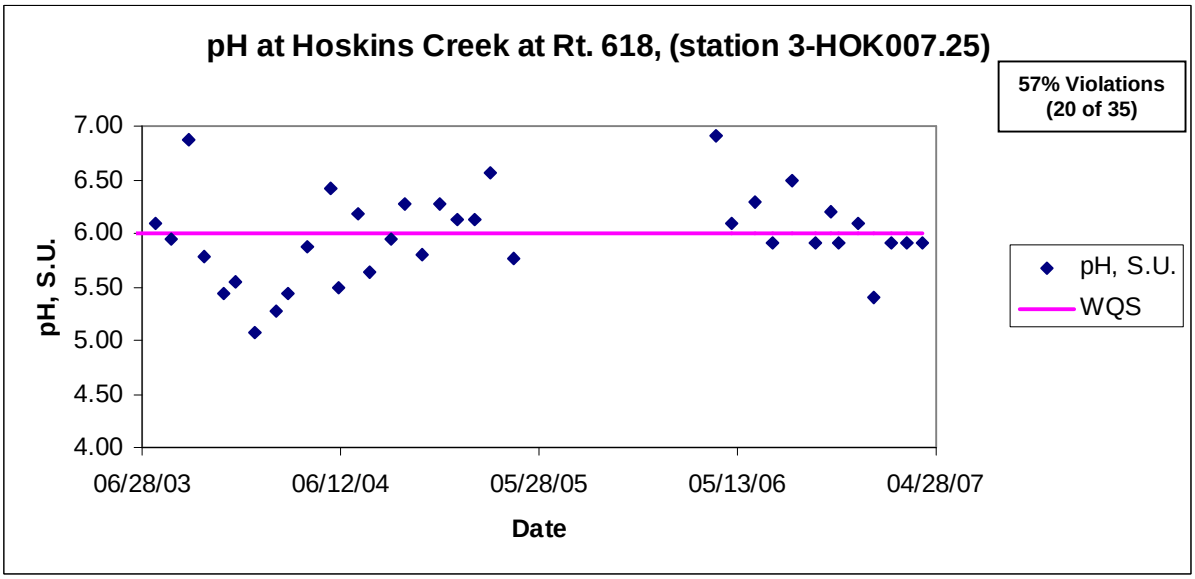


Figure 5. Time series of pH at Hoskins Creek at Rt. 618, (station 3-HOK007.25).



3.1 Associated pH of Hoskins Creek and Tributaries

DEQ also monitored and collected pH and DO data at 2 stations from upper mainstem Hoskins Creek, 3 tributaries and 2 tidal stations close to the head of tide for the assessment of low pH due to the natural conditions. Station 3-CRC001.38 was monitored twice in 2003 because it was a probabilistic benthic macroinvertebrate site, and the two pH values are not depicted graphically. These two pH values may be seen as minimum and maximum pH values for this station in Table 3. Remaining associated stations with pH data are presented in Figures 6-11 below.

Figure 6. pH at Hoskins Creek at Rt. 620, 3-HOK013.94.

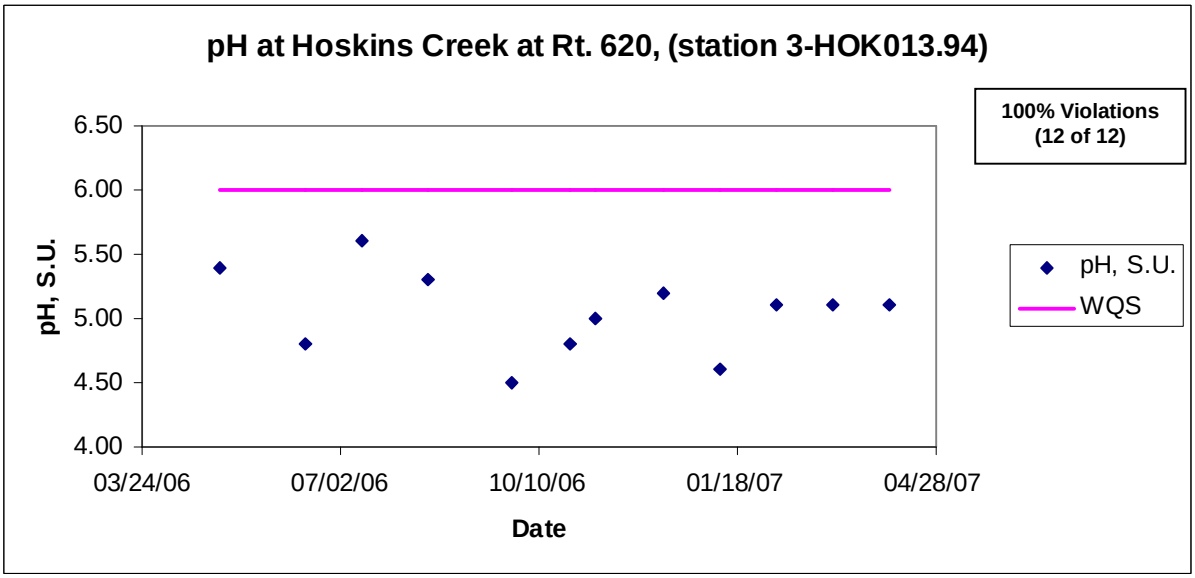


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Figure 7. pH at Hoskins Creek at Rt. 626, 3-HOK014.48.

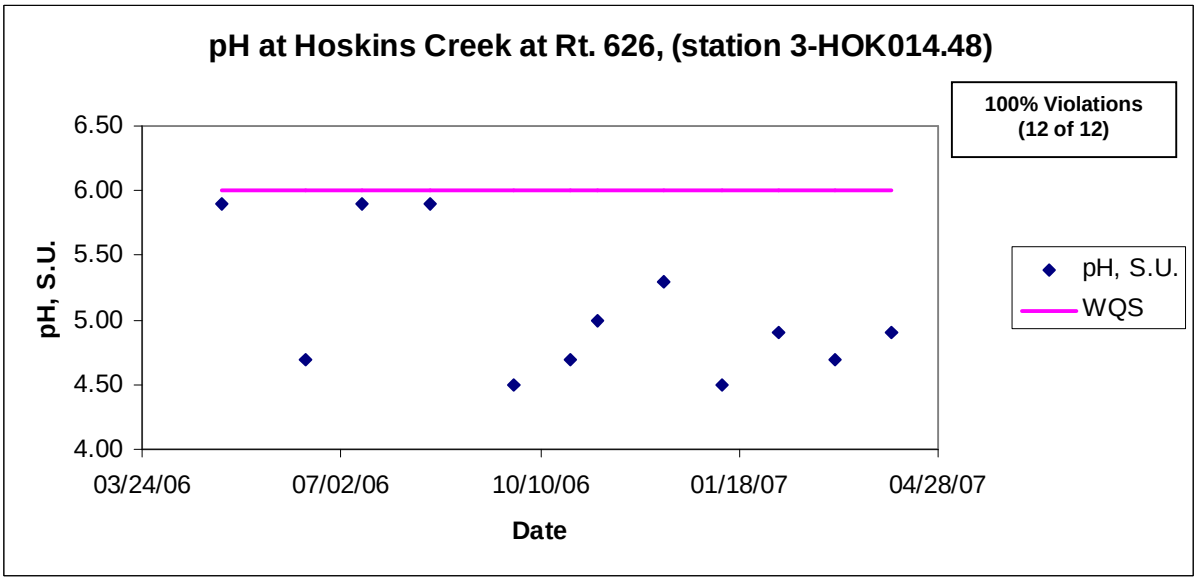


Figure 8. pH at UT (north) to Hoskins Creek at Rt. 620, 3-XGX000.04.

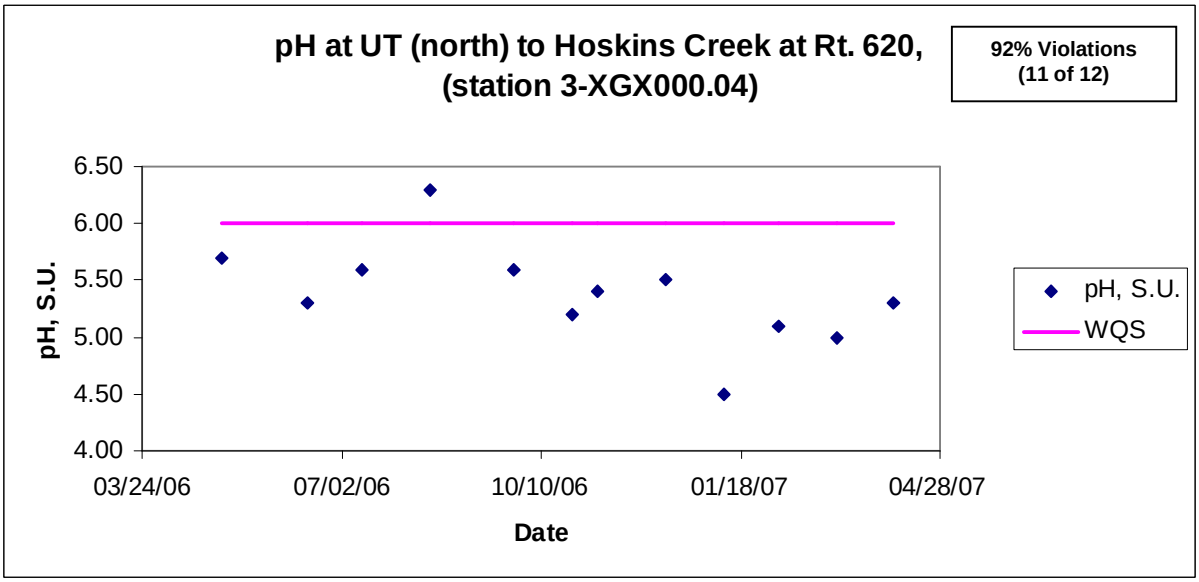


Figure 9. pH at UT (south) to Hoskins Creek at Rt. 620, 3-XGY000.23.

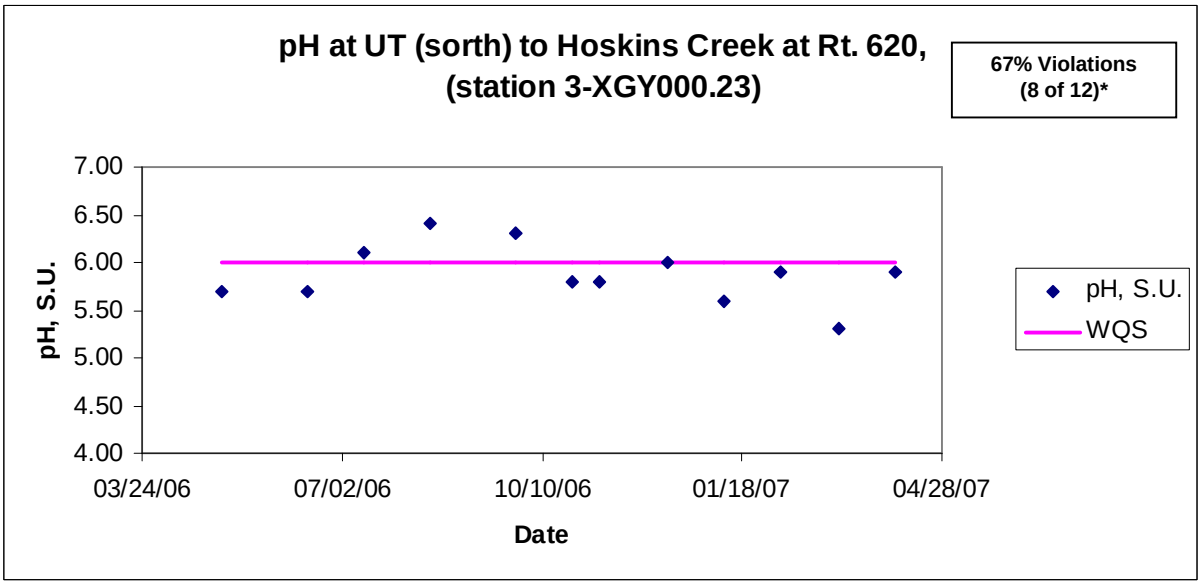


Figure 10. pH at tidal Hoskins Creek at Rt 659, 3-HOK003.61.

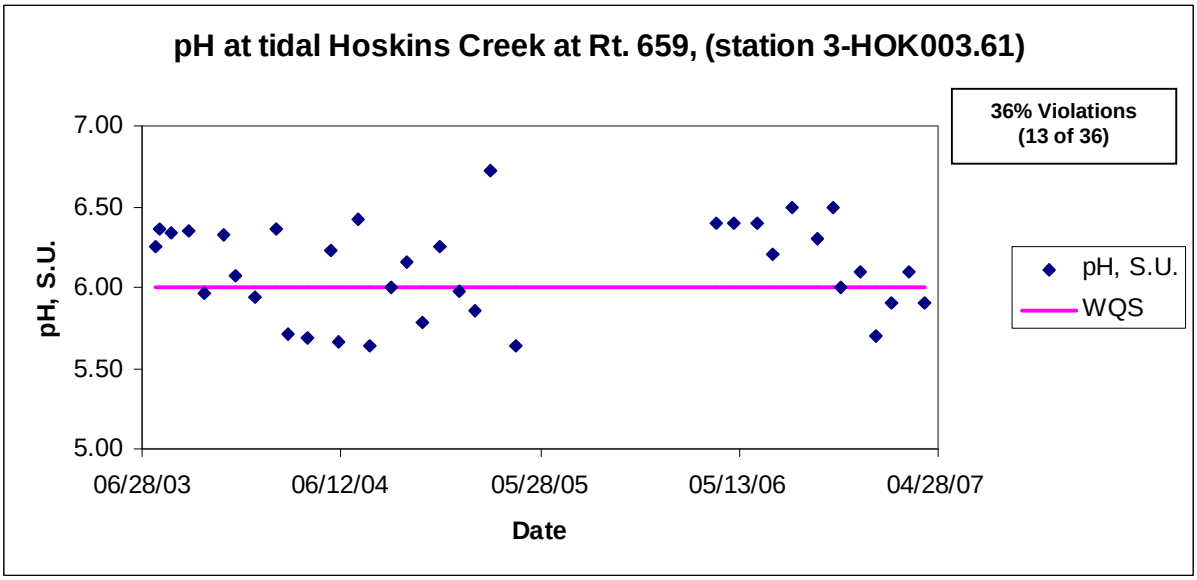
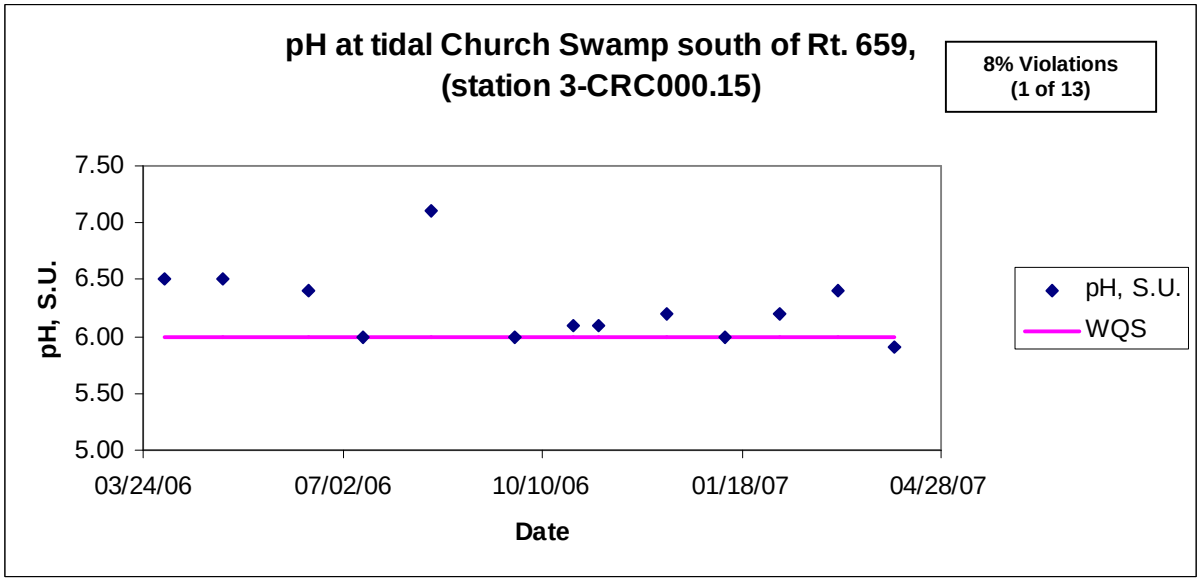


Figure 11. pH at tidal Church Swamp south of Rt 659, 3-CRC000.15.



All stations except one monitored on Hoskins Creek and tributaries exceeded the water quality standards for pH in more than 10 percent of visits. Tidal Church Swamp had 8 percent violations, therefore only non-tidal Church Swamp should be considered impaired for pH.

4. Water Quality Standard

According to Virginia Water Quality Standards (9 VAC 25-260-5), the term *"water quality standards means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water*

Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.)."

As stated above, Virginia water quality standards consist of a designated use or uses and a water quality criteria. These two parts of the applicable water quality standard are presented in the sections that follow.

4.1. Designated Uses

According to Virginia Water Quality Standards (9 VAC 25-260-10A), *"all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."*

As stated above, Hoskins Creek must support all designated uses and meet all applicable criteria.

4.2. Applicable Water Quality Criteria

The applicable water quality criteria for DO and pH in the Hoskins Creek watershed are an instantaneous minimum DO of 4.0 mg/l and pH from 6.0 SU to 9.0 SU, as in Table 4.

Table 4. Applicable water quality standards

Parameter	Minimum, mg/l	Maximum, mg/l
pH	6.0	9.0

If the waterbody exceeds the criterion listed above in more than 10.5 percent of samples, the waterbody is classified as impaired and natural conditions must be determined or a TMDL must be developed and implemented to bring the waterbody into compliance with the water quality criterion.

5. Assessment of Natural Conditions Affecting low DO - Process for determining if DO and pH impairments in free-flowing streams are due to natural conditions.

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen-restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen- depleting processes. The level of pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity. Conditions in a stream that would typically be associated with naturally low DO and pH include slow-moving, ripple-less waters or wetlands where the decay of organic matter produces organic acids. These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems. The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below.

Step 1. Determine slope and appearance.
Step 2. Determine nutrient levels.
Step 3. Determine degree of seasonal fluctuation (for DO only).

Step 4. Determine anthropogenic impacts.

The results from this methodology (or process or approach) will be used to determine if the stream should be re-classified as Class VII Swamp Waters. Each step is described in detail below.

Procedure for Natural Condition Assessment of low pH and low DO in Virginia Streams

Prepared by Virginia Department of Environmental Quality
October 2004

I. INTRODUCTION

Virginia's list of impaired waters currently shows many waters as not supporting the aquatic life use due to exceedances of pH and/or DO criteria that are designed to protect aquatic life in Class III waters. However, there is reason to believe that most of these streams or stream segments have been mis-classified and should more appropriately be classified as Class VII, Swamp Waters. This document presents a procedure for assessing if natural conditions are the cause of the low pH and/or low DO levels in a given stream or stream segment.

The level of dissolved oxygen (DO) in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen-restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. The level of acidity as registered by pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity.

Conditions in a stream that would typically be associated with naturally low DO and/or naturally low pH include slow-moving, ripple-less waters. In such waters, the decay of organic matter depletes DO at a faster rate than it can be replenished and produces organic acids (tannins, humic and fulvic substances). These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems.

The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the

likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below. DEQ staff is proposing to use this approach to implement State Water Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Waters that are shown to have naturally low DO and pH levels will be re-classified as Class VII, Swamp Waters, with the associated pH criterion of 4.3 to 9.0 SU. An associated DO criterion is currently being developed from swamp water data. A TMDL is not needed for these waters. An assessment category of 4C will be assigned until the waterbody has been re-classified.

II. NATURAL CONDITION ASSESSMENT

Following a description of the watershed (including geology, soils, climate, and land use), a description of the DO and/or pH water quality problem (including a data summary, time series and monthly data distributions), and a description of the water quality criteria that were the basis for the impairment determination, the available information should be evaluated in four steps.

Step 1. Determine appearance and flow/slope.

Streams or stream segments that have naturally low DO (< 4 mg/L) and low pH (< 6 SU) are characterized by very low slopes and low velocity flows (flat water with low reaeration rates). Decaying vegetation in such swampy waters provides large inputs of plant material that consumes oxygen as it decays. The decaying vegetation in a swamp water also produces acids and decreases pH. Plant materials contain polyphenols such as tannin and lignin. Polyphenols and partially degraded polyphenols build up in the form of tannic acids, humic acids, and fulvic acids that are highly colored. The trees of swamps have higher polyphenolic content than the soft-stemmed vegetation of marshes. Swamp streams (blackwater) are therefore more highly colored and more acidic than marsh streams.

Appearance and flow velocity (or slope if flow velocity is not available) must be identified for each stream or stream segment to be assessed for natural conditions and potential re-classification as a Class VII swamp water. This can be done through maps, photos, field measurements or other appropriate means.

Step 2. Determine nutrient levels.

Excessive nutrients can cause a decrease in DO in relatively slow moving systems, where aeration is low. High nutrient levels are an indication of anthropogenic inputs of nitrogen, phosphorus, and possibly organic matter. Nutrient input can stimulate plant growth, and the resulting die-off and decay of excessive plankton or macrophytes can decrease DO levels.

USGS (1999) estimated national background nutrient concentrations in streams and groundwater from undeveloped areas. Average nitrate background concentrations are less

than 0.6 mg/L for streams, average total nitrogen (TN) background concentrations are less than 1.0 mg/L, and average background concentrations of total phosphorus (TP) are less than 0.1 mg/L.

Nutrient levels must be documented for each stream or stream segment to be assessed for natural conditions and potential re-classification as a Class VII swamp water. Streams with average concentrations of nutrients greater than the national background concentrations should be further evaluated for potential impacts from anthropogenic sources.

Step 3. Determine degree of seasonal fluctuation (for DO only).

Anthropogenic impacts on DO will likely disrupt the typical seasonal fluctuation seen in the DO concentrations of wetland streams. Seasonal analyses should be conducted for each potential Class VII stream or stream segment to verify that DO is depressed in the summer months and recovers during the winter, as would be expected in natural systems. A weak seasonal pattern could indicate that human inputs from point or nonpoint sources are impacting the seasonal cycle.

Step 4. Determine anthropogenic impacts.

Every effort should be made to identify human impacts that could exacerbate the naturally low DO and/or pH. For example, point sources should be identified and DMR data analyzed to determine if there is any impact on the stream DO or pH concentrations. Land use analysis can also be a valuable tool for identifying potential human impacts.

Lastly, a discussion of acid rain impacts should be included for low pH waters. The format of this discussion can be based either on the process used for the recent Class VII classification of several streams in the Blackwater watershed of the Chowan Basin (letter from DEQ to EPA, 14 October 2003). An alternative is a prototype regional stream comparison developed for Fourmile Creek, White Oak Swamp, Matadequin Creek and Mechumps Creek (all east of the fall line). The example analysis under IV in this document, or the example report prepared for Fourmile Creek, illustrate this approach. For streams west of the fall line, a regional stream comparison for 2004 analyses encompasses Winticomack, Winterpock, and Chickahominy Rivers.

7Q10 Data Screen

If the data warrant it, a data screen should be performed to ensure that the impairment was identified based on valid data. All DO or pH data that violate water quality standards should be screened for flows less than the 7Q10. Data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly. Only those waters with violation rates determined on days with flows > or = 7Q10 flows should be classified as impaired.

In some cases, data were collected when flow was 0 cfs. If the 7Q10 is identified as 0 cfs as well, all data collected under 0 cfs flow would need to be considered in the water quality assessment. In those cases, the impairment should be classified as 4C, impaired due to

natural conditions, no TMDL needed. However, a reclassification to Class VII may not always be appropriate.

III. NATURAL CONDITION CONCLUSION MATRIX

The following decision process should be applied for determining whether low pH and/or low DO values are due to natural conditions and justify a reclassification of a stream or stream segment as Class VII, Swamp Water.

If velocity is low or if slope is low (<0.50%) AND
If wetlands are present along stream reach AND
If no point sources or only point sources with minimal impact on DO and pH AND
If nutrients are < typical background

- ❖ average (= assessment period mean) nitrate less than 0.6 mg/L
- ❖ average total nitrogen (TN) less than 1.0 mg/L, and
- ❖ average total phosphorus (TP) are less than 0.1 mg/L AND

For DO: If seasonal fluctuation is normal AND
For pH: If nearby streams without wetlands meet pH criteria OR if no correlation between in-stream pH and rain pH,

THEN determine as impaired due to natural condition
→ assess as category 4C in next assessment
→ initiate WQS reclassification to Class VII Swamp Water
→ get credit under consent decree

The analysis must state the extent of the natural condition based on the criteria outlined above. A map showing land use, point sources, water quality stations and, if necessary, the delineated segment to be classified as swamp water should be included.

In cases where not all of these criteria apply, a case by case argument must be made based on the specific conditions in the watershed.

5.1 Preliminary Data Screen for Low Flow 7Q10

The 7Q10 flow of a stream is the lowest streamflow for seven consecutive days that occurs on average once every ten years. The first step for low flow 7Q10 screening is to determine the most accurate 7Q10 available. The 7Q10 flow for the Hoskins Creek and tributaries may be estimated by a drainage area ratio of the Hoskins Creek watershed (29.6 mi^2) with the 7Q10 flow at the long-term continuous gaging station Piscataway Creek near Tappahannock, VA, (USGS: 01669000), with a drainage area of 28.0 mi^2 and a 7Q10 of 0.50 cfs. Thus the 7Q10 of Hoskins Creek is estimated at 0.53 cfs.

The DO Instantaneous Water Quality Standard applies **AT** 7Q10 flow, but **NOT** below 7Q10 flow (9 VAC 25-260-50 ***). Therefore in streams where the 7Q10 > 0.0 cfs, DO less than 4.0 mg/l taken at flows below 7Q10 are not water quality standard violations. However, in streams where the 7Q10 = 0.0 cfs, **ALL** DO data < 4.0 mg/l are standard violations, even if the flow = 0 cfs when the DO was taken.

No Hoskins Creek and tributaries pH standard violations were obtained at flows below 7Q10. One non-violation pH 6.72 S.U. on 7/17/2002 at station 3-HOK011.45 was obtained below 7Q10, but this was not deleted from the dataset per the protocol above, therefore no data were removed.

5.2 Low slope, Swamps, Wetlands or Large Forested Areas

The slope of Hoskins Creek and the five largest tributaries was determined. The low slope for these streams ranged from 0.17% to 0.41% (Table 5), which is less than the defined low slope criteria of 0.50%. Decomposition of the large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watersheds increase oxygen demand and lower DO as they decay, as well as contribute to the low pH by creation of natural weak organic acids (tannic, humic and fulvic acids) during decomposition of the decaying vegetation. These are not considered anthropogenic impacts. Criddlin and Church Swamps and UT Hoskins Creek at RM 9.45 were included in the report because their slopes meet the criteria for swampwater and each contains areas of forested land with swamps and heavy tree canopy throughout the watershed like the other tributaries in the study. DEQ did not have a monitoring station on these swamps because they lack public access.

Table 5. Calculated percent slopes for Hoskins Creek and Tributaries.

Stream	% Slope	Upstream Elevation (Feet) at Rivermile (RM)	Downstream Elevation (Feet) at Rivermile (RM)
Hoskins Creek	0.19	100’ at RM 17.40	5’ at RM 8.06
UT XGX to Hoskins Creek	0.34	90’ at RM 1.65	60’ at RM 0.00
UT XGY to Hoskins Creek	0.17	60’ at XGY RM 0.42	50’ at Hoskins RM 12.71
Criddlin Swamp	0.31	50’ at Criddlin Sw RM 0.50	30’ at Hoskins RM 10.41
Church Swamp	0.29	30’ at RM 2.00	5’ at RM 0.34
UT Hoskins Creek at RM 9.45	0.41	30’ at UT RM 0.31	20’ at Hoskins RM 9.30

Visual inspections of Hoskins Creek and tributaries revealed swampy areas with heavy tree canopy. Decomposition of vegetative matter from large swampy areas lowers DO and pH as decay occurs. (Figures 12-14). See the title page photo of tidal Hoskins Creek showing heavy marsh between the head of tide and the confluence of Church Swamp.

Figure 12. Hoskins Creek, Rt. 620, Upstream.

Figure 13. UT XGX to Hoskins Creek at Rt. 620, Upstream.

Figure 14. UT XGY to Hoskins Creek, Rt. 620, Upstream.

5.3 Instream Nutrients

The VADEQ collected nutrient data from the original listing station 3-HOK011.45 located on Hoskins Creek from June 2001 to March 2003, which are shown in Table 6. Data points below the limit of detection were averaged using half the detection limit. The average nutrient concentrations are below the USGS (1999) national background nutrient concentrations in streams from undeveloped areas levels of nitrate < 0.6 mg/l; TN (TKN + NO_3 + NO_2) < 1.0 mg/l; and TP < 0.1 mg/l. These low nutrient levels are not indicative of human impact.

Table 6. Instream Nutrients of Hoskins Creek at Rt. 717, 3-HOK011.45

Parameter	Average Conc.	Number
Total Phosphorus	**0.054 mg/l**	(n=12)
Orthophosphorus	0.034 mg/l	(n=12)
Total Kjeldahl Nitrogen	0.575 mg/l	(n=12)
Ammonia as N	0.057 mg/l	(n=12)
Nitrate as N	**0.286 mg/l**	(n=12)
Nitrite as N	0.009 mg/l	(n=12)
TN (TKN + NO_3 + NO_2)	**0.870 mg/l**	(n=12)
Nitrite + Nitrate, Total as N	0.295 mg/l	(n=12)

5.4 Impact from Point Source Dischargers and Land Use

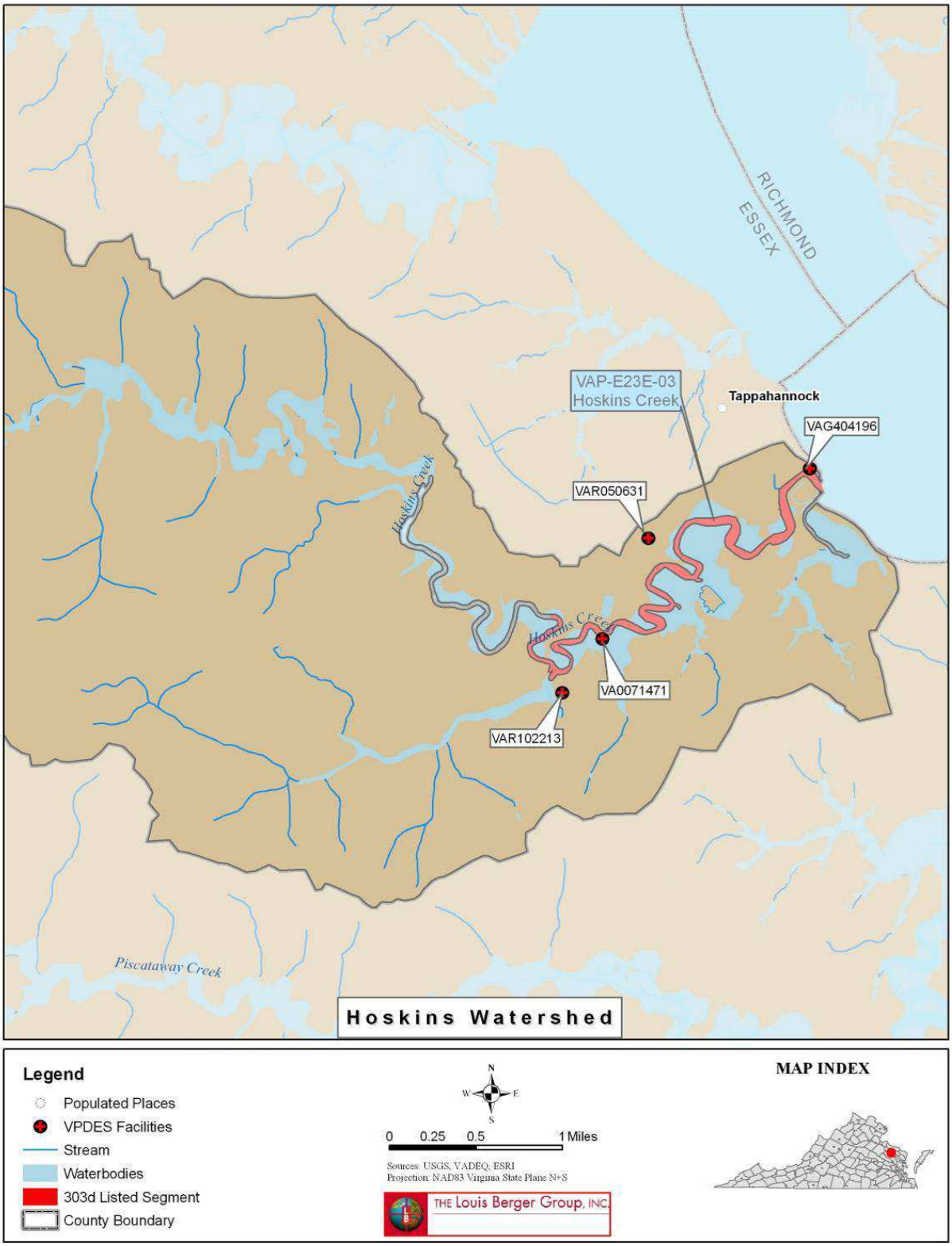
There are 4 active permitted (1 VPDES; 1 VAG; 2 VAR) Point Source facilities in the Hoskins Creek and tributaries watershed (E23E and R). These are shown in Table 7 and Figure 15. All are located in the tidal portion of the watershed below the confluence with Church Swamp and so may only be expected to have any impact on upper tidal station 3-HOK003.61 above Church Swamp on incoming tides. The Town of Tappahannock STP (VA0071471) submitted 94 monthly effluent pH data points to VADEQ during the period of July 2002 to April 2010. The minimum was pH 6.1 S.U. and the maximum was pH 8.7 S.U. This facility would not lower pH in the upper tidal portion of Hoskins Creek. The VAG is a private residence with a design flow < 0.001mgd located at the mouth of tidal Hoskins Creek at the Rappahannock River. The owner collects

pH once annually and keeps the data onsite. The stormwater construction permit was in effect from June 2004 to June 2009 and was terminated in June 2009. The stormwater industrial permittee was located 0.75 mi from the tidal portion of Church Swamp and discharged only in significant rainfall events. These facilities are not expected to impact non-tidal Hoskins Creek pH at all, and are expected to have no significant impact to upper tidal Hoskins Creek pH.

Table 7. Permitted dischargers located within the Hoskins Creek and tributaries watershed.

Table 7: Permitted Facilities within the Hoskins Creek Watershed			
Permit #	**Permit Type**	**Facility Name**	**Receiving stream**
VA0071471	VPDES	Town of Tappahannock STP	Hoskins Creek
VAR102213	Stormwater- Industrial	Rappahannock Tractor	Hoskins Creek/UT
VAG404196	General Permit	Residence	Hoskins Creek
VAR050631	Stormwater- Construction	H Warshow and Sons Incorporated	Hoskins Creek

Figure 15. Permitted dischargers located within the Hoskins Creek and tributaries watershed.



Urban areas compose approximately 2.4 percent of the land base, almost all of which occurs downstream of the impaired segment in the tidal portion of the watershed. This leaves an insignificant portion of the urban

land use in the non-tidal portion of the watershed. Agriculture makes up approximately 24.5 percent of the watershed. The watershed is predominately forested (63.5 percent), with 5.6 percent wetlands and 0.2 percent open water. Land use was not considered to have significantly impacted the swampwater conditions of Hoskins Creek and its tributaries.

6. CONCLUSION

The following decision process is proposed for determining whether low DO values are due to natural conditions:

If slope is low (<0.50) AND
If wetlands or large areas of forested land are present along stream reach AND
If no point sources or point sources with minimal impact on DO AND
If nutrients are < typical background
- ❖ average (= assessment period mean) nitrate less than 0.6 mg/L
- ❖ average total nitrogen (TN) less than 1.0 mg/L, and
- ❖ average total phosphorus (TP) are equal to or less than 0.1 mg/L AND

If nearby streams without wetlands meet DO criteria,

THEN determine as impaired due to natural condition
→ assess as category 4C in next assessment
→ initiate WQS reclassification to Class VII Swamp Water
→ get credit under consent decree

No Hoskins Creek and tributaries pH standard violations were obtained at flows below 7Q10. One non-violation pH 6.72 S.U. on 7/17/2002 at station 3-HOK011.45 was obtained below 7Q10, but this was not deleted from the dataset per the established protocol, therefore no data were removed.

The low slope for these streams ranged from 0.17% to 0.41%, which is less than the defined low slope criteria of 0.50%. Decomposition of the large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watersheds contribute to low pH by creation of natural weak organic acids (tannic, humic and fulvic acids) during decomposition of the decaying vegetation, and increase oxygen demand and lower DO as they decay. These are not considered anthropogenic impacts. Criddlin and Church Swamps and UT Hoskins Creek at RM 9.45 were included in the report because their slopes meet the criteria for swampwater and each contains areas of forested land with swamps and heavy tree canopy throughout the watershed like the other tributaries in the study.

Hoskins Creek and its tributaries exhibit low nutrient concentrations below national background levels in streams from undeveloped areas, which are not indicative of human impact.

There are 4 active permitted (1 VPDES; 1 VAG; 2 VAR) Point Source facilities in the Hoskins Creek and tributaries watershed (E23E and R). All are located in the tidal portion of the watershed below the confluence with Church Swamp and so may only be expected to have any impact on upper tidal station 3-HOK003.61 above Church Swamp on incoming tides. The Town of Tappahannock STP (VA0071471) submitted 94 monthly effluent pH data points to VADEQ during the period of July 2002 to April 2010. The minimum was pH 6.1 S.U. and the maximum was pH 8.7 S.U. This facility would not lower pH in the upper tidal portion of Hoskins Creek. The VAG is a private residence with a design flow < 0.001 mgd located at the mouth of tidal Hoskins Creek at the Rappahannock River. The owner collects pH once annually and keeps the data onsite. The stormwater construction permit was in effect from June 2004 to June 2009 and was terminated in June 2009. The stormwater industrial permittee was located 0.75 mi from the tidal portion of Church Swamp and discharged only in significant rainfall events. These facilities are not expected to impact non-tidal Hoskins Creek pH at all, and are expected to have no significant impact to upper tidal Hoskins Creek pH. Visual inspections of Hoskins Creek and tributaries revealed swampy areas with heavy tree canopy. Decomposition of vegetative matter from large swampy areas lowers pH and DO as decay occurs.

Urban areas compose approximately 2.4 percent of the land base, almost all of which occurs downstream of the impaired segment in the tidal portion of the watershed. This leaves an insignificant portion of the urban

land use in the non-tidal portion of the watershed. Agriculture makes up approximately 24.5 percent of the watershed. The watershed is predominately forested (63.5 percent), with 5.6 percent wetlands and 0.2 percent open water. Land use was not considered to have significantly impacted the swampwater conditions of Hoskins Creek and its tributaries.

Based on the above information, a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is indicated for Hoskins Creek and its non-tidal tributaries from their headwaters to the head of tide located in waterbody identification codes (WBID, Virginia Hydrologic Unit) E23R, a total of 66.22 rivermiles. Also a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is indicated for tidal Hoskins Creek from the head of tide downstream to the confluence of Church Swamp, totaling 0.052 mi^2, located in waterbody identification codes (WBID, Virginia Hydrologic Unit) E23E. If there is a 305(b)/303(d) assessment prior to the reclassification, Hoskins Creek and these tributaries will be assessed as Category 4C, Impaired due to natural condition, no TMDL needed.

DEQ performed the assessment of the Hoskins Creek tributaries low DO and low pH natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

7. References

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